ORGANIZATIONAL ASPECTS OF MULTICRITERIA DECISION MAKING

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PREFACE

Decision making processes include organizational or institutional aspects in which human judgement and reflexion of the decision maker are formed. Thus, analysis of organizational behaviors in the decision making processes has been attracting increasing attention since the 1950s.

Now studies on institutional structure of the decision making processes are on a new line of research projects in the System and Decision Sciences Area of IIASA. Especially in Task 1 : Decision and Planning Theory, the project on Decision Processes and Hierarchical Structure intends to analyze institutional effects on the decision making processes and the scrutinize how the decison maker acts to **balance** conflicting objectives. This paper is modestly concerned with providing some basic ideas for this direction, especially for multi-objective extension of preference theory in organizational analysis. Special stresses are placed on operational meaningfulness and practical usefulness of the conceptual framework.

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I. INTRODUCTION

Multicriteria systems analysis has been developed since the 1960's in accordance with the increasing complexities of human society and environment. In the early period, the main intention was multiobjective extensions to the mathematical programming. (Cochrane and Zeleney, 1973, Cohn and Park, 1975).

Also, preference theories based on von Neumann-Morgenstern type normative utility theory have been developed. Raiffa (1968) and Schlaiffer (1969,1971) developed decision analysis under uncertainty with some probabilistic experimental methods. Luce and Suppes (1965), Fishburn (1970) and many other people, provided theoretical analysis for preference structure. The decision analysis has been extended to multi-attribute utility theory.

Multiple criteria decision analysis with conflicting objectives has been developed by Keeney (1974) and Kenney and Raiffa (1976). They provided representation theorems for multiattribute utility functions in additive and multiplicative forms under preferential and utility independence assumptions. Chance lottery techniques for indifferent experiments to assess the scaling constants for deriving the multiattribute utility functions were also developed. Many applications of their multiattribute utility function method have been presented.

Assessing preference structure on large-scale complex systems is usually a major undertaking. The decisionmakers are facing a cognitive complexity and the obscure consequences. Learning and adaption procedures to clarify the recognition of the preference structures makes the constructive processes of preference functions more effective and more reasonable. Additional works due to embedding sequential procedures for information processing will be greatly reduced by computer utilizations for aiding decisions. Thus, computer programs for decision analysis have also been developed. Schlaifer (1971) presented the Manecon collection for elementary representation of single attribute utility functions and probability distributions and for the calculation of expected utility functions. Sicherman (1975) developed a computer package for assessing and calculating multiattribute utility functions. It is called MUFCAP.

A new integrated computer program has been developed by Sakawa and Seo (1980a,b) called ICOPSS/1. This program is especially effective for representing and calculating a nested structure of the multiattribute utility functions in a hierarchical, multilevel system, together with an assessment of various types of single attribute utility functions and probability distributions.

However, preference structures are recognized as a result of comparative evaluation of the consequences of human actions. Human actions are always carried out within organizations: human actions are an organizational behavior. Thus, organizational aspects of decision making must be scrutinized explicitly.

In this paper we intend presenting a brief review of some theoretical points to be examined for the extension of multicriteria decision analysis to organizational aspects. In Section 2, the main characteristics of multicriteria decision analysis are scrutinzied in contrast to conventional approaches. The term "multicriteria decision analysis" is often, and easily, used, without posessing its essential properties. This situation is largely misleading and must be corrected. In Section 3, a conceptual framework of organizational decision making is presented and conditions for organizational equilibrium and stability are examined.Some aspects to be elucidated for operationally converting structural concepts to function terms are briefly reviewed. In Section 4, some concluding remarks are presented.

II. PECULIARITIES OF MULTICRITERIA DECISION ANALYSIS.

Multicriteria decision problems cannot be reduced to multisectoral or multivariate optimization problems. Multicriteria decision making has special characteristics which are related to the comparison of preference on a non-dominated surface. Generally, the decision maker cannot find the "best" solution among alternative plans in a feasible region. To choose a preferred point as a compromised solution on the non-dominant or Paraeto-admissible surface is the main subject of the multicriteria decision problems. Thus, the question is, <u>how</u> does one find the preferred point? <u>How</u> does one derive the preferred point with rational procedures? This is the starting point of multicriteria decision analysis. In other words, <u>how</u> the decision is made is a crucial aspect in multicriteria decision making differing from classical approaches in which <u>what</u> decision is made is the matter of most interest, Thus, the theoretical approach to human preference has several characteristics. First, the theory must be able to provide principles for deciding priorities among alternative choices of actions in order. For this purpose, the magnitude of preferences must be measured numerically and difference among preferences must be compared with each other in sufficiently large or cognitively evident ranges. Second, sequential learning and adaptation procedures for improving alternative plans and for finding better compromized solutions must be embedded in the search processes for deriving the most preferable point, as is it not possible to ascertain preference functions in advance. Thus, constructive procedures or selective search processes for seeking the preferred solution is unavoidable to multicriteria decision analysis. This is called "procedual rationality" or "procedual criteria" in decision sciences, as opposed to "substantive rationality" or "substantive criteria" in conventional optimization theory1/. Third, during this search process, the substance of human preferences and its recognition are forming and evolving2/. Goals or target points are transferable with additional information. However, complete information cannot be expected. Also, in the process of constructing the preferred solution, reflection on human preference in indispensable. Thus, some ambiguity is unavoidable in this process. The decisionmaker must always cope with incompleteness and uncertainty of information and knowledge as well as the complexity and impreciseness of human judgement. The decisionmaker cannot depend on supremal optimality or omniscient rationality.

A multicriteria decision problem $\mathscr{D}$ is a satisfaction probmen which is expressed in the following form:

$$\mathscr{D}(X,\rho,\Omega) \leq \beta(\Omega) \qquad (1)$$

$$\mathscr{D}: X\times\rho\times\Omega \rightarrow V \quad \text{and} \quad \beta:\Omega \rightarrow V \qquad (2)$$

where X is a set of decision variables; ρ is a set of external information with certainty; Ω is a set of uncertain information and fuzziness; V is a set of numerical values of preferences;and β is a tolerance function. Decision problem (1) shows the satisfaction criterion with "bounded rationality". Multicriteria decision making is performed with satisfying principles instead of perfect optimization principles in classical operations research.

1/ "Procedual rationality" is concerned with the effectiveness of procedures of choosing actions. On the contrary, "substantive rationality" is related to a set of special actions to be chosen as those most appropriate (Simon 1978). In other words, the former is "process-oriented" and the latter is "outcome-oriented".

2/ In this sense, "The decision is an important state in the evolution of a process, and providing Decision-Aid means taking part in this process" (Roy 1977).

III. CONCEPTUAL FRAMEWORK FOR ORGANIZATIONAL ASPECTS OF MULTICRITERIA DECISION MAKING.

The organizational goal of decision making as a purposeful system has a qualitative property which is called organizational attractiveness to constituents or, in short, attractiveness. Now, the problem is to factorize the attractiveness into its components, structure them, and quantify them in operational, meaningful and observable terms. In the following, some basic notions for factorizing and structuring the organizational goal are presented. Some devices for numerical calculation are also suggested.

First, behavioral structure of the organization as the goal-seeking system is composed of three basic components: goals(subgoals), actions and agents. The organizational triangular (OT) structure composed of these components is a condition for the existence of an organization. From the point of view of attractiveness, these elements are scrutinized in terms of self-actualization or expectation on the subjective side, and of performance or expectation-realization on the objective side. The Subjective-Objective relationship is constructed in a hierarchical multilevel system. A means-end hierarchy is superimposed on it for crystallizing the expectation-realization hierarchy for constituents.

Second, for operating organizations, a behavioral triangular (BT) structure is considered; inducements, contributions and returns, which are attributed to the above basic components. These attributes must be in equilibrium if organizations are to operate continuously. We call it the continuing or on going condition of organizations.

Third, if organizations are stable, it is necessary to keep a utility balance among the three, abovementioned major attributes. The utility balance (UB) triangular structure among inducement utility, contribution utility and return utility is concepturized in the March-Simon sense but in its extention to trilateral relationships based on the attribution of the OT structure. Assuring the utility balance is the stability condition of organizations.

Fourth, the OT structure includes conflicts within each component: among objectives, among alternatives, and among actors. Thus, a conflict triangular (CT) structure is configurated. If organizations are 'well behaved',conflict finding as well as conflict solving processes must be imbedded into decision making processes. Conflict finding and conflict solving are the "well-functioning" conditions of organizations.

Now, from among the basic components of the OT structure, the action is chosen as a key factor for evolving organizations in dynamic processes combined with social development. We define the action as the one which is represented as participating in the organization. Let us define a vector of the action a as the one with motivation to participate. An overall value function V(a) is defined according to the BT structure as follows:

$$V(a) = V[f(I,C,R)] \tag{3}$$

where I (inducements), C (contributions) and R (returns) are all vector. Evaluating the equation (3) is a matter of multi-criteria decision making.

The BT structure is analyzed in the following forms:

$$I = F_I\{A(g),\ k(\pi),\ Q(m)\} \tag{4}$$

$$C = F_C(B,E) \tag{5}$$

$$B = B\{d(\alpha-s),E\} \tag{6}$$

$$R = F_R(z,n,P) \tag{7}$$

where

A : acceptability of organizational goals

g : transparence of organizations

k : continuance of organizations

π : profitability

Q : malleability of organizations

m : managerial capability

B : working capability

E : organizational environment for promotion and encouragement

d : personal development capability

α : aspiration level of constituents

s : current working capability

z : status in the organization

n : monetary revenue and other compensations

p : friendship and social comfort.

These variables and functions are all vectors in which many elements are included and are also time-variant. Namely the behavior of these compoinents in a specified time largely correspond to the latest information. Thus, the speed of response is supposed to be negligible.

Based on the BT structure, the value function V(a) can be assessed in terms of multiattribute utility functions in a nested UT structure.

$$V(a) = U\{U(I),\ U(C),\ U(R)\} \tag{8}$$

$$= U[U\{u(g),u(k),u(Q)\},\ U\{u(B),u(E)\},\ U\{u(x),u(y),u(p)\}] \tag{9}$$

By assessing these u-values with scaling constants and checking if the utility balance among attributes exist, the decision-maker knows whether or not the organization is under the stability conditions. If the utility balance exists, all the arguements in equation (3) are supposedly under the going conditions and the organizations are still evolving in the dynamic processes.

Note that the utility balance does not depend on marginal equalization conditions in the classicial equilibrium analysis. It is only necessary to evaluate the differences among utilities in numerical terms to some extent being sufficiently large and evident to discern with human cognitive power. Thus, the utilities are equalized based on a discrete analysis for satisfying the stability conditions.

However, there is a problem in pursuing this direction because almost all the variables are obtained from unquantified data with subjective judgements. Thus, a device for quantifying unquantified data must be constructed. A special device must be developed for treating uncertainty or fuzziness, which are classified as follows:

(I) fuzziness of data set

(II) fuzziness of cognitive powers in socio-psycological sense.

(III) fuzziness of environmental events.

For coping with (I), subjective scales for composite data sets can be used for assigning the numerical ranges of the attributes in the process for assessing the single attribute utility functions (Keeney 1975, Seo and Sakawa 1979).

Facing the fuzziness (II) of cognitive power, the decision-makers cannot depend on the complete transitive comparability axiom which is fundamental to traditional utility theories in the von Neumann-Morgenstern sense. An alternative axiom on partial comparability has been presented by Roy (1977). Based on the partial comparability axiom, preferences are modeled in terms of four binary relations for a set of ordered pairs (x_k, y_k) for special value of k of every $x,\ y \in X(\{a\})$. (X is a set of decision variables to be avaluated with any kind of preference and is regarded as an outcome of a set of alternative actions a).

I : Indifference : reflexive and symmetric

$(x_k R\, x_k$ for every $x \in X$, and

if $x_k R\, y_k$ then $y_k R\, x_k$ for every $x,y \in z)$

p : Strict preference : irreflexive and asymmetric

(not $x_k R\, x_k$ for every $x \in X$, and

if $x_k R\, y_k$ then not $y_k R\, x_k$ for every $x,y \in X)$

L : Large preference : irreflexive and antisymmetric

(not $x_k R\, x_k$ for every $x \in X$, and

if $x_k R\, y_k$ and $y_k R\, x_k$ then $x_k = y_k$ for every $x,y \in X)$

m : Incomparability : irreflexive and symmetric

(not $x_k R\, x_k$ for every $x \in X$, and

if $x_k R\, y_k$ then $y_k R x_k$ every $x,y \in X)$

Note that in these concepts transitivity is not included. In particular, it is necessary to establish the threshhold of human discriminant power for manipulating the indifference and the large preference. The indifference threshhold is denoted as $\delta_k^{\pm}(s_k)$ and presumed preference $(I \cup L)$ threshhold is shows as $\omega_k^{\pm}(s_k)$, where s_k is a preference level assigned to a numerical values x_k. The above concepts are redefined with those concepts as follows:

I : Indifference $s_k(x_k) + \delta_k^{-}(x_k) \leq s_k(y_k) \leq s_k(x_k) + \delta_k^{+}(x_k)$

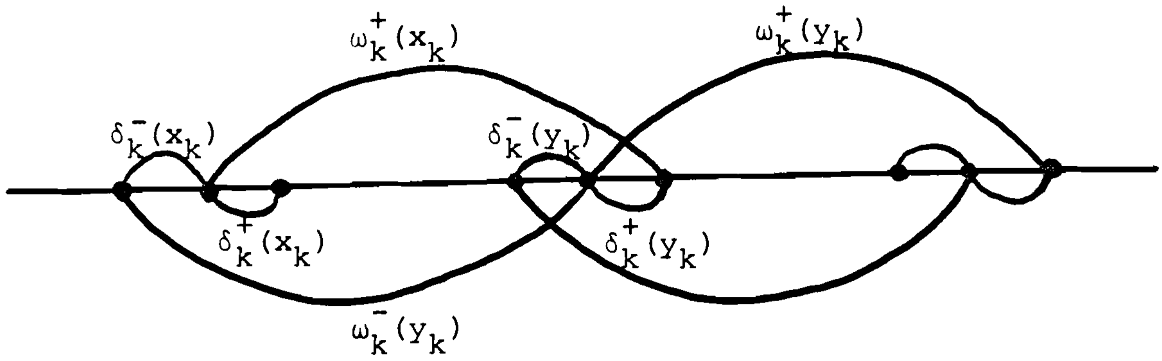
L : Large preference $s_k(x_k) + \delta_k^{+}(x_k) < s_k(y_k) \leq s_k(x_k) + \omega_k^{+}(x_k)$

$$s_k(x_k) + \delta_k^{-}(x_k) > s_k(y_k) \geq s_k(x_k) + \omega_k^{-}(x_k)$$

where, for simplicity:

$\delta_k^{\pm}\{s_k(x_k)\} = \delta_k^{\pm}(x_k)$ and $\omega_k^{\pm}\{s_k(x_k)\} = \omega_k(x_k)$

The diagram shows large preference relationship between x_k and y_k.



With these devices, outranking relations with fuzziness are constructed. Fuzzy outranking relation R_A^ω for a decision problem A is defined in terms of the presumed preference relation based on the partial comparability axiom. A set of alternative actions a for the decision problem A is evaluated in comparison with another set a' in terms of the degree of outranking $\gamma(a',a)$ where $\gamma(a',a) = \psi(v(a') - v(a))$, v is an element of the overall value function V(a) and ψ is a conversion function of the numerical difference among value functions to outranking relations.

According to the definitions of I and L,

(i) $\gamma(a',a) = 3$ if $\omega^-(a) > v(a') - v(a) > \omega^+(a)$

(ii) $\gamma(a',a) = 2$ if $\omega^-(a) \leq v(a') - v(a) \leq \omega^+(a)$

(iii) $\gamma(a',a) = 1$ if $\delta^-(a) \leq v(a') - v(a) \leq \delta^+(a)$

(iv) $\gamma(a',a) = 0$ otherwise

(i) is certain outranking with strict preferences,

(ii) is fuzzy outranking with presumed preference,

(iii) is fizzy outranking with indifference, and

(iv) is certain non-outranking with incomparibility.

By calculating the numerical values of outranking relations and summing them up, the decisionmaker can check the degree of fuzziness included in the assessment of the UT structure (8)~(9).

Fuzziness is accrued from organizational slack which is nothing but a consequence of maladjustment in organizational systems. Thus, we call the numerical value expressing the degree of fuzziness organizational slack index (OSI), or in short, slack index (SI). Slackness check is indispensable in organizational multicriteria decision making.

For treating another difficulty (III), environmental factors are examined as uncertain qualities for which subjective probability distributions are assessed because statistical experiments based on mass observations are not usually available for organizational decision making. A prompt response of organizations to changing environmental factors is required for keeping the stability conditions. The method for assessing the subjective probability distributions has been developed by Schlaifer (1969) and others. An example for using this method has been provided by Seo and Sakawa (1979).

IV. CONCLUDING REMARKS

Multicriteria decision making (MCDM) is concerned with systems analysis facing complex problematique in which many heterogeneousities of the components are included. They are not only commensurate in comparable terms but conflicting with each other. Facing this situation,presenting reasonable procedures for problem finding and problem solving processess is the main subject of multicriteria decision analysis.

The organizational aspect of MCDM is basically composed of an abstract goal such as attractiveness and its components. A main aspect of organizational multicriteria decision analysis is to factorize the conceptual structure and to convert the structural concepts to functional attributes and their relations. For clarifying and comparing the organizational achievements in terms of human preference, performance of actions or solutions must be observable and measurable in tangible terms. Multiattribute utility analysis including conflict solving processess is one of the most well developed and promising approaches. However, for articulating fuzzy elements or ambiguousness which are unavoidable due to the organizational slack accrued as a result of maladjustment in the organizational behavior, weak ordering of preference relation will be given up and threshhold analysis of human cognitive power in socio-psychological sense must be introduced. Evaluating the slack index (SI) is an indispensable aspect peculiar to organizational decision making.

Computer-assisted decision analysis will largely enhance efficiencies for assessing and calculating the expected utility values implicated in an organizational structure. From a theoretical point of view, extended devices for manipulating the organizational slack and for assuring organizational equilibrium will be expected.

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